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U. S. DEPARTMENT OF AGRICULTURE.

REPORT
OF
THE CHEMIST
FOR
1902.

BY
H. W. WILEY.

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REPORT OF THE CHEMIST.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., September 8, 1902.

SIR: I have the honor to submit herewith my report of the operations of the Bureau of Chemistry for the fiscal year ended June 30, 1902, together with an outline of the proposed work for the fiscal year ending June 30, 1903, and an estimate of the probable expenses of the Bureau for the fiscal year ending June 30, 1904.

Respectfully,

H. W. WILEY, *Chemist.*

Hon. JAMES WILSON, *Secretary.*

WORK OF THE YEAR.

On the 1st of July, 1901, the old Division of Chemistry, the first of the Divisions organized in the Department of Agriculture, became by act of Congress and Executive order the Bureau of Chemistry. The enlargement of the scope of the work by reason of this change rendered necessary an entire reorganization of the working force and a redistribution of the subjects of investigation. To this end, with the approval of the Secretary of Agriculture, the work of the Bureau was divided into groups, and laboratories were established to which each group of work was assigned. The laboratories organized for the year's work were as follows:

FOOD LABORATORY.

To this laboratory, of which Mr. W. D. Bigelow was made chief, was confided the study of the composition, digestibility, and adulteration of human foods in the largest sense of that term, including foods in the ordinary sense, beverages, and condiments. Also to this laboratory was assigned the study of substances added to foods for any purpose whatever, of which preservatives, coloring matters, and leavening agents are types.

During the fiscal year of 1901-1902 the examination of imported foods, which was begun in 1898, was brought to a close, and the results were embodied in a report to the Secretary of Agriculture, and by him transmitted to the President. In the course of this work the examination of imported olive oils led to the observation that several oils were adulterated which have always been reported pure by laboratories using the standard methods usually employed in the examination of salad oils. The work on the subject of olive oils was therefore greatly increased. It is proposed to issue a publication on this

subject during the coming year which will include the results of the examination of imported oils obtained through the customs officers and in the open market in this country, of domestic oils obtained in the open market, and of both foreign and domestic oils which were obtained from the manufacturers, with as full details as possible regarding the process of manufacture and, wherever possible, with affidavits as to their purity.

The results of the examination of about 350 samples of canned meats during the preceding year were compiled and published in Part X of Bulletin No. 13 of the Bureau of Chemistry.

Some work has been done with the canned soups which were examined during the preceding fiscal year. The results have been compiled and the manuscript will shortly be submitted for publication.

A careful study of tropical fruits grown in Cuba and Porto Rico has been under way since early autumn, and it is proposed to examine as many typical fruits of those islands as can be obtained during one calendar year. This work is of more value because of the presence of a member of the food laboratory in Havana during the greater part of the year, who personally secured the samples. In addition to the examination of these fruits, samples of commercial fruit products have been obtained and will shortly be subjected to analysis in the laboratory.

In connection with the studies of the Pomologist relating to the question of cold storage of fruit, the food laboratory examined eight varieties of apples at the time of their introduction into the storage warehouse, again when they began to ripen, again when fully ripe, and finally when overripe. Owing to the press of work in the laboratory when this investigation was under way, the results were not as complete as were desired. Some valuable information was gained from them, however, and the way is well marked out for a more detailed investigation of the same question during the present year.

In cooperation with the Virginia experiment station, a number of varieties of apples, as well as pomace and must produced from them in the manufacture of cider, have been examined by the food laboratory. The results of this work have been incorporated by Mr. William B. Alwood in his bulletin on the manufacture of cider, which is now in press.

During the latter part of the fiscal year the wines for which prizes were awarded at the Paris Exposition of 1900, were examined in the food laboratory. These analyses are of great interest because of the fact that they are the only complete analyses of American wines that have been made for a number of years. All available analyses of American wines were collected by the Bureau of Chemistry two years ago and published in Bulletin No. 59. Some of the results there given are relatively recent, but the majority of them were obtained a number of years ago, some as early as 1861.

A comparison of the latest results obtained with those included in Bulletin No. 59 indicates that marked improvements have been made in the methods of fermentation employed in the United States. The percentages of volatile acid and sugar are much lower, while the percentage of glycerol is much higher in the recent examinations than in the earlier ones. Perhaps we are not warranted in saying that the industry on the whole has been improved to the extent indicated by such a comparison, but the number of samples examined was sufficient to warrant making the statement somewhat general. It is highly desirable that this work be extended.

An important part of the work of the food laboratory during the last fiscal year was that done at the request of other Departments. This includes samples from the subsistence departments of the Army and Navy and nonalcoholic beers from the Attorney-General and sheriffs in the Indian Territory. At the request of the Treasury Department an investigation was also made of pineapples, in order to determine as nearly as possible the amount of sugar that is added to the canned pines imported into the United States from the Bahamas and the Straits Settlements. To determine this a large number of imported canned pines were obtained, and also ripe pines, from as many localities as possible, including Florida, Cuba, Porto Rico, and the Bahamas. Arrangements have also been made to have samples of pines taken at Singapore preserved according to directions and shipped to the laboratory for examination.

The food laboratory has done an important work during the last fiscal year in collecting, investigating, and comparing methods for the examination of a large variety of foods. This work was taken up at the request of the Association of Official Agricultural Chemists, in which the chief of the food laboratory is at present the referee on food adulteration. He has worked in cooperation with 13 prominent food chemists of the United States and Canada in the preparation and collection of these methods. The results of their labor have been published as Bulletin 65 of the Bureau of Chemistry, which forms a better laboratory manual for the examination of the subjects it includes than any single reference book that has been published. Since this bulletin was published, three additional subjects have been treated by the chemists to whom they were assigned.

ROAD MATERIAL LABORATORY.

This laboratory, of which Mr. L. W. Page was made chief, was established in collaboration with the Office of Public Road Inquiries, and is not yet fully equipped. The installation of the laboratory began in December, 1900, and it was impracticable to begin work for several months, on account of the time necessary for even a partial equipment. Therefore the fiscal year ended June 30 last is the first year of operation of this laboratory.

The object of the road material laboratory is to obtain results, by means of physical and chemical tests, from small samples of road materials, to aid the road builder in selecting the most suitable material available, and to advise him as to the best methods of construction to be used in his work.

Up to the present time it has been possible to test only materials used for macadam, gravel, and clay roads. To properly meet the various conditions of traffic and climate to which roads are subjected with suitable road materials, it is necessary to carefully study the chemical and physical properties of these materials, and it is here that the principal work of the road material laboratory lies. In a broad sense, the value of any road material is dependent upon the degree to which it possesses certain physical and chemical properties, and these properties often depend on a peculiar chemical composition. The work of the laboratory therefore comes under three principal heads, viz, physical tests, for determining the degree to which a material possesses the essential physical properties necessary for good roads; chemical analyses, together with the chemical investigation of certain essential properties; and petrographic determinations of the various

rock samples, so that they can be properly classified according to their mineral composition.

The most important of the physical properties which are made subjects of investigation are: Hardness, or the property possessed by a material to resist the wear caused by the abrasion of the wheels of vehicles and horses' feet, and toughness, or the adhesion between the fine particles of a material which gives it the power to resist fracture when subjected to the blows of traffic. This property, while distinct from hardness, is intimately associated with it and can, in a measure, make up for a deficiency in hardness. Hardness, for instance, would be the resistance offered by a material to the grinding of an emery wheel; toughness, the resistance to fracture when struck with a hammer. Cementing value, which is probably the most important property to be sought for in macadam rocks, gravels, and clays, is the property possessed by the dust of these materials to act, after wetting, as a cement to the coarser fragments composing the rock, bringing them together to form a smooth, impervious shell over the surface. The degree to which a material absorbs water is also an important property, as is also the density of macadam rock.

All samples received at this laboratory during the past year have been subjected to the necessary tests for determining the degree to which they possess the above properties. They have also been analyzed chemically or petrographically, as the particular case required, and properly classified. Besides these standard tests, several new ones have been proposed and investigated.

In addition to the regular tests certain lines of investigation have been taken up, which, it is hoped, will be of benefit to the road builder. Among the most important of these is a study of burnt clays, together with the cementing value of clay. The results obtained from this work warrant the expectation that satisfactory roads can be built of moderately burned clay at a comparatively small cost. If this be true it will be of great benefit to those citizens of our country who live in districts where no hard materials for road building are available. It is the purpose of this laboratory during the present year to build an experimental road of burnt clay, in collaboration with the Office of Public Road Inquiries, and thus test in a practical way the results obtained in the laboratory.

During the past fiscal year 150 abrasion tests have been made, 184 cementation tests, 88 chemical analyses, 180 petrographical analyses, 150 absorption tests, and the same number of specific densities. Two hundred and seventy-one miscellaneous samples were received. These samples have come from all parts of the United States, including some of our new possessions, and in no instance has a sample been solicited in any way. They have come almost exclusively from practical road builders, endeavoring to lessen the cost and improve the quality of their work.

DENDRO-CHEMICAL LABORATORY.

Mr. W. H. Krug was made chief of this laboratory. It was organized in collaboration with the Bureau of Forestry for the purpose of instituting a complete chemical study of forest products in all their economical relations. The work done during the year ended June 30, 1902, was divided into the following groups:

(1) Researches, in cooperation with the Association of Official Agricultural Chemists, on analytical methods applied to feeding stuffs, and also on methods of analysis of tanning materials.

(2) Preparation and analysis of 300 samples of wood and bark taken from sections of *Quercus prinus*, *Quercus rubra*, *Quercus alba*, *Quercus velutina*, and *Tsuga heterophylla* (hemlock) supplied by the Bureau of Forestry.

(3) Examination of nine unidentified tree secretions from the Philippine Islands, to determine their possible identity with gutta-percha.

(4) Partially completed investigations on a series of tree secretions submitted by the Philippine Bureau of Forestry, which were fully identified before shipment.

(5) A comparative study of the properties of synthetic and native camphor.

(6) An investigation of methods for the extraction of guaiac resin from lignum-vitæ chips and sawdust.

(7) An extensive study of certain products obtained by a new process devised for the distillation of waste pine wood. The plant where this system is in operation was visited, and the principle of the process was made the subject of a special report.

(8) A partially completed study of the chemical composition and physical properties of American wood pulps and wood-pulp papers obtained from the manufacturers.

(9) A microchemical and histological study of the development of the cellular tissues of certain oaks which has been carried on by Mr. B. J. Howard. This work is almost completed and will be accompanied by a review of the literature on the subject.

(10) Preliminary work on the availability of certain hitherto unused woods as a source of wood pulp.

(11) Preliminary work on chemical methods for killing useless timber.

(12) Analysis of 22 samples of indian corn for the Division of Botany.

(13) Determination of the cellulose and pentosans in 30 samples of fruit for the food laboratory.

(14) The preparation of a card index covering all chemical literature bearing on dendro-chemistry.

SUGAR LABORATORY.

Mr. G. L. Spencer was made chief of this laboratory, and the analytical work for the year ended June 30, 1902, included analyses of sirups, sugars, sugar beets, sugar cane, etc. The total number of analyses was 2,439, distributed as follows:

Miscellaneous samples	32
Sugars in cooperation with the Treasury Department	775
Sugars for the War Department	5
Sugar cane	146
Sugar beets grown on the Department's farm	80
Sugar beets from the State experiment stations	45
Sugar beets, miscellaneous samples	1,338
Sorghum cane	7
Melons	11
Total number of samples	2,439

The work of the sugar laboratory included also the preparation of replies to letters concerning the sugar industry in general, the editing of the manuscript for Farmers' Bulletin No. 135, "Sorghum sirup manufacture," and the correction of the proof sheets and the revision of Farmers' Bulletin No. 52, "The sugar beet."

The purpose of the sugar laboratory is to study from a chemical point of view all aspects of the sugar industry, including therewith those nearly allied carbohydrates, starches. The work covers practically the chemical studies and related techno-chemical industries having for their object the manufacture of sugar or starch, or their products, in any form, or for any purpose. The sugar industry is preeminently one which has depended for its development on chemical research, and it is safe to say that the beet would still be only a garden vegetable, devoid of any practical utility for sugar making, had it not been for the impetus given to its development by chemists.

The most important collaborative work of the sugar laboratory has been in the study of the composition of the sugar beet as affected by environment, in which this laboratory has had the assistance of the Weather Bureau in collecting and preparing the meteorological data in various parts of the country where experiments were conducted; also the valuable collaboration of the North Carolina, Iowa, Michigan, Utah, Virginia, Indiana, Wisconsin, Kentucky, and the two New York experiment stations, which have consented to furnish the agricultural data in connection with the work, and also to duplicate the chemical analyses.

Other interesting and valuable work of the sugar laboratory has been the collaborative study of the composition of muskmelons as affected by environment. In this work the laboratory has had the collaboration of the following experiment stations for the agricultural data and also for duplicating the chemical analyses: New Jersey, California, Colorado, Delaware, Arizona, North Carolina, Kentucky, Indiana, Texas, and Maryland.

INSECTICIDES AND AGRICULTURAL WATER LABORATORY.

Of this laboratory Mr. J. K. Haywood was made chief. In some instances it has been necessary to put more than one group of investigations in one laboratory, as the equipment of the Bureau would not permit the formation of a separate laboratory for each subject of study. For this reason the subjects of insecticides and agricultural waters have been placed in one laboratory.

During the year ended June 30, 1902, the study of the composition of the springs on the Government reservation at Hot Springs, Ark., undertaken in cooperation with the Interior Department, was completed, and the results compiled and forwarded to the Secretary of the Interior, who had them published as Senate Document No. 282. This work shows the composition of all the hot springs, explains their medicinal qualities, and gives very complete methods for the analysis of waters of this class.

In collaboration with the Division of Entomology, this laboratory has made analyses of about 160 samples of insecticides, fungicides, and disinfectants, gathered from all parts of the United States. The work done upon this subject has been published in a popular form as Farmers' Bulletin 146, and in a more technical and complete form as Bulletin No. 68, of the Bureau of Chemistry. The methods of analysis used, many of which were devised for the work, are given in the latter bulletin. The results of this work show that many of this class of preparations are of little or no value for the purpose intended, while many more that could just as well be prepared by the farmer are sold at an exorbitant rate. Objection has been made on the part of various manufacturers of proprietary articles used as insecticides and

fungicides to the right of the Department to make analyses of their products and to publish the results. In this connection, it may be mentioned that it is not the object of these investigations to in any way injure the business of any reputable manufacturer. It is hard to see, however, how publicity in regard to these matters can be objected to. The interests of the farmers and others using these bodies is of first importance in these investigations. If it be true that many of these bodies fail to possess the properties attributed to them, the manufacturer is as much interested in knowing this as the consumer, because it may be assumed that no reputable manufacturer would desire to continue to place upon the market an article which is less valuable than it is claimed to be. If, however, occasion should ever arise where a manufacturer, after being informed of the nature of a body, should desire to continue to sell a practically worthless preparation, it seems only proper that the public should be informed in regard to the exact character of the article offered.

In every instance, before publication, the analyses of these bodies are submitted to the proprietors, and they have always ample opportunity to make any representations in regard to the matter which may seem proper to them. Especially, if our analysis is in error, and this must necessarily sometimes happen, the proprietor of the article has the opportunity to point out the mistakes which have been made, in which case an attempt is always made to rectify them before publication. It seems, therefore, that studies of this kind are well suited to protect both the interests of the manufacturer and the consumer, and that no reasonable objection can be raised against them.

During the past year work was begun, also in collaboration with the Division of Entomology, on the amount of free arsenious oxid which may be present in Paris green used for spraying, without injury to the foliage. This work will be of great value and will enable the State experiment stations to determine the value of any particular sample of Paris green for spraying purposes.

Work was also begun during the past year upon a study of the arsenic content of papers, wall papers, tapestries, and fabrics of various kinds. It is a well-known fact that the presence of large quantities of arsenic in these goods is injurious to health.

In collaboration with the Office of Experiment Stations (irrigation investigations), work was begun upon a study of the water used for irrigation purposes in the Western States, and especially in the rice belt of Texas and Louisiana. It is expected that this work will be of immense benefit to rice growers in enabling them to determine what waters are most suitable for their purpose. An important feature of this work is a study of the effect of the backing up of sea water consequent upon the pumping of large quantities of water out of the low streams of Louisiana. If the content of salt in the river rises to such an extent as to be injurious to the rice crop, the irrigation investigations office will endeavor to make suggestions and assist the rice growers to other means of irrigation.

Many samples of insecticides and fungicides have been analyzed during the year in this laboratory, together with numerous samples of irrigation waters. In several instances the water supply of small cities has been examined to determine its healthfulness.

The chief of this laboratory having been appointed referee on insecticides and fungicides for the Association of Official Agricultural Chemists, a large amount of work was done in cooperation with that

association. Many new methods of analysis of this class of compounds were devised and tested and samples for analysis sent to 14 different chemists for purposes of comparison.

SOIL LABORATORY.

Since the chemistry of the soil is the foundation of agricultural chemistry, a special laboratory, with Mr. C. C. Moore as chief, has been established to study the chemical composition of the soil and the best methods of analysis.

This laboratory has continued in a line of soil investigations which were commenced in the Division of Chemistry about seven years ago. Its specific work has been to devise methods whereby the amount of mineral matter in a soil in a condition to be assimilated by plants may be estimated, the purpose being to forecast and supply those ingredients which would have been found deficient by the growing plant. After a very elaborate series of pot experiments upon the growth of oats, beans, and buckwheat, a scheme for the determination of the amounts of phosphorus pentoxide and potash available for the plant was devised.

In the early part of the year a unification of the laboratory studies was undertaken by a direct application to the actual conditions of field crops. Accordingly, a series of plot experiments was begun in Tennessee upon the growth of oats. Tennessee was selected for these experiments because of the many varieties of soil and geological formations found in that State. About 25 plots were grown, ranging the full length of the State. Samples of the soil and subsoil were taken at the time of seeding. These samples were analyzed, and from the results a conclusion was drawn as to the amount of phosphorus and potash which would probably be utilized by the plants in the course of their growth. At the maturity of the crop a sample of soil was secured from an accurately defined area. From the analysis of this sample the amount of mineral matter removed was calculated, and the results were compared with the forecast as made from the previous analysis of the soil. Very significant results were obtained, and owing to the vast importance of such an investigation it was decided to extend the scope of the work and verify the results by an extensive application of the theory throughout the United States.

Accordingly, a cooperative plan of study was arranged. A circular outlining the nature of the work was prepared and sent to the various agricultural experiment stations. Twenty-eight stations agreed to undertake the work. The plan, in brief, is as follows: Each station selected a typical soil, preferably one that had received no fertilizer, which was considered the best suited for the purpose. Four adjoining plots of cereals were sown—spring wheat, oats, rye, and barley. From the center of the plots and over an area of about 4 square feet samples of soil were secured to three successive depths of 9 inches. The soils and subsoils were shipped to this laboratory, where a portion was used for the experimental culture in pots and the remainder redistributed among the cooperating stations for analysis and study.

At maturity the crops are to be harvested and forwarded to this laboratory, where they will be analyzed and the amount of mineral matter removed will be calculated.

This is probably the most extensive chemical investigation of methods to determine the fertility of soil which has been undertaken. Each

cooperating station was supplied with 54 samples, representing the soils and subsoils from 27 States, and with the analyses of the four varieties of cereals grown on these soils. There was also supplied to each station a piece of apparatus designed by this laboratory, whereby 12 samples of soil may be simultaneously subjected to specified constant conditions of digestion, viz, a definite temperature and the continuous agitation of the soil in its solvent. With this equipment the cooperating stations will endeavor to verify the scheme of analysis, as outlined by this laboratory, and in addition such theories as have been or may be proposed by authorities on this subject.

A study of some of the sugar-cane soils of Georgia and Florida was made in this laboratory during the past year. Sixty-five samples of these soils were subjected to a complete chemical study, and the data obtained have been compiled and incorporated in a bulletin on the manufacture of cane sirup.

The analytical work for the past year consisted of the analysis of 140 soils and 375 crop samples.

FERTILIZER LABORATORY.

Intimately connected with the laboratory devoted to the study of the composition of soils is the one which has in charge the study of domestic and commercial fertilizers. To this laboratory, of which Mr. E. G. Runyan is chief, samples of soil are referred when the object is simply to determine the quantity of plant food or fertilizing material which they contain.

The work done in this laboratory during the year ended June 30, 1902, included complete or partial analyses of the following materials:

Mineral or natural products	26
Fertilizers	40
Aqueous soil extracts	6
Soils	112
Miscellaneous samples	37
Total	221

The purity of chemicals purchased for the use of the Bureau has also been determined in this laboratory, and a record has been kept of all samples received in the soil, fertilizer, and various other laboratories.

A considerable amount of time and labor has been given to the testing of new and proposed methods of analyzing and valuing ashes and other fertilizing materials, much of this work being carried on in cooperation with the Association of Official Agricultural Chemists.

œNOLOGICAL INVESTIGATIONS.

This Bureau has continued during the year ended June 30, 1902, the œnological investigations of the previous year in collaboration with Mr. William B. Alwood, of the Virginia Agricultural Experiment Station. The chemical work in connection with these investigations was done chiefly in the laboratory of this Bureau, but we are indebted also to Mr. R. J. Davidson, the chemist of the Virginia Agricultural Experiment Station, for a large amount of work which he gratuitously contributed to these investigations. This work was classified under two heads, viz:

First. The collection and forwarding of various fruits for chemical analysis with a view to a complete study of the composition of American fruits. This work was done with the special object of gathering

necessary data to assist in the study of the technique of cider, wine, and vinegar fermentation, so that we may be better able to handle the large amount of our fruits falling below merchantable grade, and to determine the value of certain varieties for the manufacture of the products mentioned.

Second. The isolation and study of the organisms which cause fermentation, both vinous and acetic, and also malfermentations which tend to destroy the products sought to be secured and conserved. In this study the prime data sought are the chemical changes produced in fermenting fruit musts or saccharine solutions of all kinds, and the determination of the best methods of bringing about these chemical changes in the most practicable manner, and conserving with certainty the desirable products formed from further changes by reason of malfermentation.

Under the first head, a considerable number of different varieties of apples has been collected and analyzed during the year. This has served for the beginning of a comprehensive study on the chemistry of fruits. In the course of this preliminary work it has been found that the methods of analysis are not well perfected, and as a consequence it has become necessary to take up this whole subject anew. This work will be continued on all our native fruits and berries which have commercial importance.

Under the second head, a considerable number of alcoholic ferments, belonging to the genus *Saccharomyces*, both from foreign wines and ciders and those of American production, has been separated and reduced to pure cultures. The study of these organisms as to their chemical reaction on fruit musts and saccharine solutions is well under way and promises most interesting scientific and economic results. In the study of the alcoholic ferments proper, numbers of organisms have been detected and isolated which are closely related to the above-mentioned genus *Saccharomyces*, but which from the nature of their reaction upon fruit musts are denominated malferments, because they destroy or injuriously alter those products which it is desired to conserve. The critical study of these organisms awaits a convenient time.

This kind of work on fermentations is too new a field of investigation to warrant a positive statement in regard to its importance, further than to say that it is studied in Europe in the most assiduous manner in the Government laboratories, and makers of wines, ciders, and vinegars assert that the laboratory results are used by them with the greatest benefits. In the experiments in the use of pure cultures of the alcoholic ferments at the Virginia Agricultural Experiment Station most excellent ciders have been produced.

There is a further application of this investigation, viz, the employment of these and allied organisms for the inversion of starch, in the manufacture of commercial compressed yeasts, in the inversion of nonfermentable sugars to fermentable forms, and in the differentiation of sugars by the use of specific organisms brought to a state of pure culture. This line of inquiry promises to be of great importance, both in the chemical laboratory and in the practical application of chemistry to the arts and manufactures.

MISCELLANEOUS INVESTIGATIONS.

As in previous years, the Bureau of Chemistry has been called upon during the past fiscal year to make a number of analytical and other

investigations for other Bureaus and Divisions of the Department and for other branches of the Government. Some of these investigations are of such a character that they are referred to the special laboratory appropriate in each case. Many, however, have been of such a character as not to fall within the lines of work of any of the special laboratories, and have been investigated by or under the direction of the assistant chief of the Bureau.

As a noteworthy example, there may be cited from the work of the past fiscal year investigations undertaken at the request of the Division of Entomology, to ascertain the extent of the danger from fire and explosion attending the use of carbon disulphide as an insecticide. The results of this work have been published in Farmers' Bulletin No. 145.

Perhaps the most important class of these miscellaneous investigations is the control, by means of chemical and physical tests, of materials purchased by this and other Departments of the Government. Many large corporations, both municipal and private, are establishing as thorough a scientific control as practicable over all purchases of supplies made by them. It is to be regretted that instead of leading in this movement most if not all of the Executive Departments of the Government have failed to make any considerable use of this valuable means of controlling the quality of materials purchased. This is of especially great importance for the Government, because practically all supplies are purchased on the basis of competitive bids, a system which requires the utmost precision in all specifications.

Progress has been made, however, as is evidenced by the increasing number and variety of materials submitted to this Bureau by various branches of the Government for examination in regard to purity, quality, etc. Among the notable examples of the past fiscal year may be mentioned extensive investigations relative to canceling inks for the Post-Office Department, the analysis of samples of coal for the Interior Department, etc.

The work included not merely the analysis of samples submitted, but also investigations undertaken with a view of obtaining data for the formulation of specifications which will not only give analytical results more meaning and value, but which will enable the bidders and purchasing officers to agree in regard to the exact meaning of specifications. Rigid specifications are of great importance, not only for the protection of the Government, but also for the protection of bidders of the best class. Advantage will accrue to the Government because the quality of supplies furnished can be accurately ascertained. On the other hand, bidders will be benefited by the removal of all doubt as to the quality of goods to be furnished. Bidders of the best class will therefore be protected from the competition of vendors of inferior goods.

The supervision of the sugar laboratories of the ports of Philadelphia, New York, and Boston, assigned a few years ago by an agreement between the Secretary of the Treasury and the Secretary of Agriculture to this Bureau, has been continued. A sample from each of these laboratories is sent each day for comparative analysis. Each month a summary of the analyses of these samples is compiled in order to determine the reliability and the accuracy of the work. From time to time, as the exigencies of the service may require, personal inspection is made of the sugar laboratories and comparative polarizations secured on the samples of sugar and standard quartz plates, in

order to insure the accuracy of the instruments in use. When it is considered that the duties on imported sugars amount in round numbers to \$60,000,000 annually, and that these duties are laid in accordance with the polarizations of the sugar imported, the importance of securing a rigid and accurate control of the processes is at once apparent.

Many other problems connected with the collection of duties have been referred by the Treasury Department to this Bureau during the past year. One of the most important of these investigations relates to the rate of duty which is levied upon imported pineapples preserved in cans. The law requires a certain rate of duty to be collected on imports of this kind when the pineapples are preserved in their own juice and a different rate of duty if sugar be added in the process of preserving. A difference of opinion having arisen between the appraisers and importers in regard to this matter, the solution of the difficulty by mutual consent has been left to this Bureau. In order to reach a conclusion large numbers of analyses of imported products, as well as of the original pines, have been necessary. This work was only partially completed at the end of the fiscal year, but will be brought to completion during the present fiscal year.

The question of the exclusion of certain articles of food which may contain injurious products has also been referred in several instances to this Bureau by the Treasury Department since, under the existing laws, such exclusion is secured only on certification from the Secretary of Agriculture to the Secretary of the Treasury that the articles in question are injurious. Investigations have been carried on during the past year relative to some of the principal preservatives, and as a result of these investigations certain regulations have been formulated by the Secretary of the Treasury respecting the use of sulphur on fruit products preliminary to desiccation, preservation, and shipment. Under these regulations, when their details are carried into effect, the wholesomeness of the imported articles is not impaired, while their appearance is rendered more agreeable by the previous application of fumes of burning sulphur. Since the process of sulphuration, which is the application of fumes of burning sulphur to fruits previous to desiccation or preservation, is practiced generally throughout the world and since when properly conducted no injurious effects are produced upon the product, it is hoped that the policy established by this Government in relation to such products will be adopted by other nations. Some American fruit products have been subjected to restriction or exclusion in foreign countries by reason of alleged application of sulphur in the manner described, and we believe that these restrictions and exclusions do not rest upon justifiable grounds.

PROPOSED WORK FOR THE YEAR ENDING JUNE 30, 1903.

The work outlined in the above report for the laboratories mentioned, and which has already received the approval of the Secretary, will be continued during the fiscal year ending June 30, 1903, as follows:

FOOD LABORATORY.

During the present fiscal year the work described in the first part of this report with olive oil, pineapples, tropical fruits and their manufactured products, the ripening of fruits, and the manufacture of

cider will be continued. Some time will be devoted to the study of polariscopic and reducing methods for the determination of sugar, in cooperation with the sugar referee of the Association of Official Agricultural Chemists.

The most important new line of work that will be inaugurated will be the study of infant and invalid foods, of which a large number is now on the market. This will be taken up early in the autumn, and will probably occupy the time of a portion of the force during the full calendar year. An examination relating to nonfermented beverages and flavoring extracts on the market will also be made.

ROAD MATERIAL LABORATORY.

During the current fiscal year the same tests referred to in the first part of this report will be carried on, and the demand for them will doubtless be much greater. Besides these tests, the necessary appliances have been installed for testing paving brick; and as the use of brick for road paving is increasing very rapidly, and as the testing of brick is most essential, this work will doubtless be one of the important features of this laboratory.

It is also intended to make certain investigations in the mixing and burning of clay for the purpose of obtaining methods for getting the necessary properties essential to good paving brick.

The testing of cements and concretes will also be an important part of the laboratory work, as concrete is not only used extensively in road foundations, but for drainpipes and sidewalks as well. The equipment for carrying on this work has been partially installed and the work will soon be taken up.

Wood blocks have long been used in Europe with great success for paving streets, and their introduction into this country, with modern methods of preserving the wood, is met with favor. When properly treated there is no material better suited to heavy traffic than wood blocks. They are sanitary, and probably give less noise and dust than any other form of pavement. The importance of investigating the proper methods of preserving wood is so essential that the subject has been taken up in collaboration with the Bureau of Forestry, and it will be made an object of study during the current year. The Bureau of Forestry has supplied this laboratory with two most essential testing machines for carrying out the physical tests on wood blocks, and the dendro-chemical laboratory of this Bureau will investigate the chemistry of the subject of wood preservatives.

The necessary expert assistance during the year will more than absorb the total allowance which has been made, and the additional funds necessary, together with all incidental expenses of the laboratory, will be supplied from the miscellaneous funds of the Bureau of Chemistry.

DENDRO-CHEMICAL LABORATORY.

The work outlined for this laboratory for the present year is as follows:

- (1) Continuation of the analytical studies on the composition of the wood and bark of certain American oaks and hemlocks.

- (2) Extension of the work on American wood pulps and wood-pulp papers in connection with the investigation on the availability of certain woods as a source of wood pulp, the ultimate object being the creation of a paper-testing laboratory which shall exercise an intelli-

gent control over the purchases of paper made by the United States Government. In connection with these plans, suitable apparatus has been designed for determining the physical properties of various papers. The work will also include extensive microscopical studies of the fibers.

(3) Cooperation with the Association of Official Agricultural Chemists on analytical methods applied to feeding stuffs and tanning materials.

(4) Continuation of investigations on the composition and commercial value of new forest products obtained in our island possessions. Arrangements have been made with the Philippine Bureau of Forestry whereby such materials will be systematically collected and sent to this laboratory.

(5) A study of the extent to which American turpentine is adulterated.

(6) An investigation of the composition and relative wearing quality of American tanned sole leather. A machine for determining the wearing quality has been built and will shortly be placed in position. Arrangements have been made for the collection of a large number of samples of such leather.

(7) A study of the effect of dry and moist heat on the physical properties of wood. At the request of this laboratory the Bureau of Forestry has purchased a Riehle testing machine, which will be placed in the road-material laboratory and will be used for comparative work.

(8) A continuation of the investigation on chemical methods for killing trees.

(9) Further studies on the chemistry and histology of the cellular tissues of the wood and bark of trees.

In addition the laboratory will, as heretofore, carry on cooperative work with the other Bureaus and Divisions of the Department, in so far as this work comes within the province of its special lines of investigation. The work on the card index embracing all literature bearing on dendro-chemistry will be continued. A review of recent progress in this field is contributed every month to Forestry and Irrigation, the official organ of the American Forestry Association and the National Irrigation Association.

SUGAR LABORATORY.

The work proposed for the current year is a continuation of the collaboration with the Weather Bureau and agricultural experiment stations in studying the effect of environment upon the chemical composition of plants. Since sugar and starch, together with other carbohydrates, make up by far the greater part of the organic matter of which plants are composed, it is evident that these studies will be carried on almost exclusively in the sugar laboratory. In addition the laboratory will make the following studies and investigations:

(1) Investigation of raw materials and products for the advancement of the sugar and allied industries. This will include an investigation of the sirup industry, with a view to the production of a more uniform product; the analysis of samples of sugar cane, sugar beets, and such other analytical work as may be necessary in a study of the problems constantly arising in these industries.

(2) The analysis of sugars in cooperation with the Treasury Department.

(3) A study of methods of analysis in cooperation with the Association of Official Agricultural Chemists.

(4) Preparation of reports and replies to inquiries relating to sugar and other carbohydrates.

INSECTICIDES AND AGRICULTURAL WATER LABORATORY.

Arrangements have been made with the Division of Entomology to continue the collaborative work on the composition of insecticides and fungicides as they appear on the market.

Work will be continued, in collaboration with the same Division, on the amount of soluble arsenious oxid which may be present in Paris green and other arsenical insecticides without injury to the foliage resulting from their use. Such work will also be taken up in collaboration with the agricultural experiment stations, since climatic conditions have a marked effect on the action of soluble arsenious oxid on foliage.

Work in collaboration with the Office of Experiment Stations (irrigation investigations) will be continued upon a study of the irrigation value of the waters of our Western streams, and especially of the waters in the rice belt of Texas and Louisiana. Samples will be collected, according to special instructions, and analyzed in this laboratory.

The work begun on a study of the arsenic content of wall papers, fabrics, etc., will be extended and pushed vigorously, and a thorough investigation of these articles on the American market will be made.

Analyses of miscellaneous samples of insecticides, fungicides, and irrigation water will be made for farmers upon application for such work.

An investigation of the mineral and drinking waters now sold upon the American market will be made. This study will be of great scientific and practical importance, since it is believed that many waters are advertised to contain ingredients possessing marked medicinal qualities which either do not contain such ingredients at all or at most only in traces. The drinking waters will also be examined as to their effect on the health of the consumer.

A study will be made of as many samples of pyrethrum as can be obtained to determine if lead or barium chromate have been added to give them a bright yellow color. This laboratory has found that these two substances are often used in insect powders, a practice which is extremely reprehensible, since it is known that both lead and chromium are poisonous to human beings when inhaled.

It is hoped that during the present year an investigation of the quality of the water used in dairies and creameries may be begun. Practical suggestions can then be made as to the purification of such water supplies, it being a well-known fact that much disease is caused by washing cans in impure water and that the keeping quality of the butter is much influenced by the character of the water supply.

SOIL LABORATORY.

The work during the current year will be a continuation of the cooperative work with the stations, as outlined in the first part of this report. This laboratory will undertake the analytical work in connection with these studies, leaving the stations free for research work.

A study of the hemp industry of Kentucky will be taken up during the present year. This will comprise an examination of the typical hemp soils, together with a study of the crops which are grown thereon. In conjunction with this chemical work an economic investigation of the hemp industry, with reference to the methods of culture, yields, manner of preparation, uses, and markets, will be made. There have been collected 80 samples of soil representing the hemp section, and at the time of harvest samples of the crops grown in the locality where the soils were obtained will be secured.

This laboratory will have its annual routine work in the analysis of the crop samples from the pot-culture experiments. In addition, it will make analyses of the soils used in the pot experiments.

DAIRY LABORATORY.

During the last year the dairy laboratory was transferred to the Bureau of Animal Industry. By the order of the Secretary of July 1, 1902, the dairy laboratory was again placed in the Bureau of Chemistry, but no appropriations have been made therefor. Previous to January 1, 1902, this laboratory was in the Bureau of Chemistry, but the expenses thereof were charged to the Bureau of Animal Industry. Now that this laboratory has been permanently restored to the Bureau of Chemistry, it is necessary to make a special estimate for its maintenance, and this has been done in the estimates which follow. Five thousand dollars will be sufficient to carry on this work for the first year, unless the collaborative work with the Bureau of Animal Industry should be larger than is anticipated. It is necessary in this work, upon which the officers of the law often depend for analytical data, to be thoroughly equipped to secure such data promptly, in order that the execution of the law may not be delayed.

ŒNOLOGICAL INVESTIGATIONS.

The importance of the œnological investigations in the manufacture of wines and ciders has already been set forth in the first part of this report. The improvement of the character of cider which has been secured is most marked, and no greater benefit could be conferred on our cider makers than the continuance of this work, in order that the best methods of fermentation and cellar treatment for ciders may be pointed out, and also that the fermentation germs which make the best flavored products may be provided and distributed to them. What is true of ciders is also true of wines, although our investigations have not yet extended further than the analysis of the wines themselves. The importance of this work is such as to warrant the establishment of a special laboratory in the Bureau of Chemistry for its conduct, and an estimate for \$5,000 for this purpose has been submitted.

MISCELLANEOUS INVESTIGATIONS.

Our increasing knowledge of the importance of microorganisms, in connection with the changes which take place in soils and manures, is constantly presenting chemical problems of great scientific interest and importance. Most of these problems are so strictly chemical in their nature that they can only be successfully investigated in a well-equipped chemical laboratory. The routine work would be facilitated, however, by the employment of a person skilled in the isolation and

cultivation of microorganisms, to assist in preparing materials for the chemical investigations.

The use of microorganisms in connection with analytical operations, and for the manufacture of various substances in the laboratory and in the factory, is a field promising rich rewards to diligent investigators and one that has hitherto been but comparatively little worked. A beginning was made in the Division of Chemistry eight years ago, when investigations relative to the organisms of nitrification and denitrification were begun. The funds available have never permitted a vigorous prosecution of these important investigations. It is believed, however, that the appropriation of the present year will permit the preparation of the material at hand for publication and a renewal of the laboratory investigations. An item is inserted in the estimates for the collaborative work with other Departments, in ascertaining the quality of goods to be purchased, and also for the investigation of the microorganisms in soils and fertilizers of interest to agriculture.

NEW WORK.

Through the liberality of Congress provision has been made for the inauguration of two very important additional lines of investigation in the Bureau of Chemistry during the current year. The first of these is the experimental study of the effect of preservatives, coloring matters, and other substances added to foods, upon the health of the consumer. To this end direct experiments will be made to determine the influence which these bodies have upon the metabolic changes which food undergoes when ingested into the human organism and which the organism itself suffers. In this connection, series of experiments will be conducted in which ordinary foods, containing none of the substances under study, will be fed under careful chemical supervision, the digestibility of the food determined, and the gain or loss in the body ascertained. The same foods will then be fed in connection with preservatives and coloring matters and other added bodies, and a similar series of observations secured.

The importance of this work is at once evident. There are certain bodies which are uniformly employed as preservatives, which are commonly supposed to be wholesome, perhaps on account of the universality of their employment. Among these may be mentioned vinegar and salt and wood smoke. Other preservatives have a real food value, such as sugar, and the use of this body as a preservative can not be open to any objection whatever. Still other preservatives have a partial food value and are stimulating. Of this class alcohol is a type. The propriety of using alcohol as a preservative is open to grave question.

The coloring matters are usually divided into mineral, vegetable, and coal-tar colors. There is a universal feeling that mineral coloring matters are objectionable, while vegetable coloring matters are not. Of the coal-tar dyes, some are certainly objectionable and others are considered unobjectionable. The time has come, however, when some authoritative data on all these subjects are imperatively demanded.

It is to be regretted that many of the investigations which have been made on these bodies have been, to a certain extent, *ex parte*. As an instance of this, it may be said that manufacturers of certain products added to foods employ experts to study the effect of these bodies upon metabolism. It is not intended to throw any doubt upon

the ability and honesty of these experts, and yet it is only human that we should assume that in cases of doubt the benefit is universally given to the employer. Again, it may be said that in certain investigations which have been made in regard to the effect of borax, there is room for suspicion that bias has not been entirely absent. It is believed that in the investigations which are contemplated in this Bureau it will be possible to eliminate the element of bias, in so far as human nature is capable of so doing, and to conduct the examination in such a way as to reach conclusions which are not influenced in any manner, neither by the person manufacturing the products, the desire of the person consuming them, nor the purpose of the chemist conducting the work. While it is not claimed that the results obtained in such a way are absolutely free of error or not subject to revision, it is claimed that they will rest upon a basis which, at least, will not be open to criticism. These experiments, in order to have convincing results, must be made with care, must be repeated frequently, and the data obtained must be carefully studied and collated. It is expected that this work will be thoroughly inaugurated before the end of the current year.

The second line of work which the Bureau will undertake will be in the study of drugs. The object of this study is to determine the composition of the drugs sold upon our markets and of the adulteration to which they are subject. Drugs which fail to come up to the standard set by the United States Pharmacopœia or drugs of a poisonous nature which have a higher percentage of the poisonous principle than is recognized by established authorities must be considered as adulterations. Drugs in order to be efficacious must have a certain composition; otherwise, in the exhibition of remedies, neither the physician, the pharmacist, nor the patient has any idea of the quantity of the active principle employed.

This work will be undertaken in hearty collaboration with the American Pharmaceutical Association, which already has a committee studying drug adulterations and the best methods of ascertaining them. The work will be divided into two portions—first, a study of the best methods of assaying drugs, and second, a study of the drug products bought in the open market, to determine their composition and the degree and extent of their adulteration. It is expected that this work will be fully inaugurated during the present year.

CLERICAL WORK.

A large increase in the amount of clerical work necessary in the Bureau has naturally resulted from the enlargement and extension of the scientific work. Although during the present year a stenographer has been added to the clerical force, it is still entirely inadequate to handle the work necessary to keep the records of the Bureau up to date and to do the calculating and other work required in connection with the publication of the bulletins of the Bureau. The mass of correspondence, together with the regular routine work, keeps the clerical force occupied to its fullest capacity, and it necessarily follows that much of the work in connection with the permanent records of the Bureau is in arrears. As in the other Bureaus, the services of a chief clerk are necessary, and I have included an item for this purpose in the estimates submitted.